IMPACT TESTING IN MELON (*Cucumis melo* L.)

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ABSTRACT

The application of Rheology to study biological systems is a new and very extensive matter, in which melon is absolutely unknown.

The goal of this work is to determine some physical characteristics of this fruit, immediately after harvest and during its conservation in cold storage. Portugal and Spain are the most interested countries in these studies, as they are important producers of melon. The varieties 'Branco da Lezíria' and 'Piel de sapo' were chosen because they are the most popular in both countries.

The fruit were studied on the day they were harvested, and then were conserved in cold storage in the "Instituto del Frío" in Madrid, and they were periodically tested again. Thus during seven days the same fruits, and new fruits, were picked up and tested. On the first day of testing we had 20 fruits to study and at the end of the testing period we had used 80 fruits.

The results from the non-destructive impact test were very significant and they may contribute to standardise methods to measure fruit maturity. These results were confirmed by those obtained from compression tests. The results obtained during the Impact tests with melon were similar to those obtained previously with other fruits. There is a close relationship between the results of the Impact tests and Compression tests.

Tests like Impact and Compression can be adapted to melon, varieties 'Piel de Sapo' and 'Branco de Lezíria', allowing us to continue further work with this species.

The great number of data obtained during performance of the tests allowed us to go on with this work and to contribute to standardise methods of measurement and expression of characteristics of a new biological product. During the "Impact damage in fruits and vegetables" workshop, held in Zaragoza in 1990, these matters were included in the priority list.

1. INTRODUCTION

Fruit and vegetable consumers have increased continuously, and at the same time they are more concerned about quality. It is a fact that quality, during harvesting, handling and transporting, decreases with the occurrence of bruises and damages. Bruises are caused by impacts and compression of fruit during these operations, being impacts the most important cause of damage and losses in fruit (Ruiz-Altisent, 1990). Thus it is important to study the mechanical properties, specialy impact responses, of biological materials as fruit. We should keep in mind that an impact force lasts less than 10 miliseconds (Ruiz-Altisent, 1986).

There are some useful non-destructive tests to lower the level of losses and that can be used to evaluate the ripeness level of the fruit as well.

The tests conducted during the work were standardised for other fruit and we tried to apply them to this new material; we should mention the Magness-Taylor test, Punction tests, Deformation tests, cutting of cylindrical shaped specimens and also measured was the sugar content and made a sensory test. It is necessary to adequate these methods, the well known and knew ly developed ones, to fruit and vegetable not studied yet, such as melon (*Cucumis melo* L.).

2. METHODOLOGY

2.1. Experimental Design

The most important fact in the developement of this work is the large number of fruit analyzed. On the first day of testing we only had 20 fruits to work with but at the last day we tested 90 fruits (Fig. 1).

All the fruits that were not destroyed were maintained in a cold chamber at the "Instituto del Frio", in Madrid and repeatedly tested. The temperature was 6ºC ± 1ºC and the Relative Humidity, 95 %.

Therefore, during this study we tried to work with the known fruits previously used, group A, and with knew ones, that were picked up from the cold chamber each day of testing, group B, during seven weeks. At the same time and using the same sample, we also made compression tests since this is one of the non-destructive tests already standardized.

We should remember that fruit, as any other biological material, are very different from each other and their mechanical properties change greatly according to the ripeness level, to the variety they belong to and to the conservation conditions (García et Ruiz-Altisent, 1988).

To study the values of the compression in both varieties we used the Method of regression Delineations (Mexia, 1990). After the first adjustment of the straight lines we made variance analyses for the values of the slope (alfa) and intercept (beta), and for the comparison of the averages we used the Multiple Method of Schéffe.

Harvest time

Cleanesing and disinfection

Selecting material (140 fruits)

1st date of tests.	Fresh fruits Destructive and non-destructive tests **TOTAL 20 FRUITS**	
2nd date of tests.	Destructive tests: 10 new fruits Non-destructive tests: 20 new fruits **TOTAL 40 FRUITS**	+ 10 from 1st date
3rd date of tests.	Destructive tests: 10 new fruits Non-destructive tests: 20 new fruits **TOTAL 50 FRUITS**	+ 10 from 1st date + 10 from 2nd date
4th date of tests.	Destructive tests: 10 new fruits Non-destructive tests: 20 new fruits **TOTAL 60 FRUITS**	+ 10 from 1st date + 10 from 2nd date + 10 from 3rd date
5th date of tests.	Destructive tests: 10 new fruits Non destructive tests: 20 new fruits **TOTAL 70 FRUITS**	+ 10 from 1st date + 10 from 2nd date + 10 from 3rd date + 10 from 4th date
6th date of tests.	Destructive tests: 10 new fruits Non destructive tests: 20 new fruits **TOTAL 80 FRUITS**	+ 10 from 1st date + 10 from 2nd date + 10 from 3rd date + 10 from 4th date + 10 from 5th date
7th date of tests.	Destructive tests: 10 new fruits Non-destructive tests: 29 new fruits **TOTAL 90 FRUITS**	+ 10 from 1st date + 10 from 2nd date + 10 from 3rd date + 10 from 4th date + 10 from 5th date + 10 from 6th date

Fig. 1. General plan for the collection of samples. We should notice that on first day the sample was of 20 fruits and on last day of 90 fruits.

2.2. Biological material

During this work we tested a new material; the melon (*Cucumis melo* L.). As it is known that the mechanical characteristics change greatly according to the variety of fruit, we decided to work with two different varieties: 'Branco da Lezíria' and 'Piel de Sapo', being the first one a very popular melon in Portugal and the other one in Spain.

Both varieties were cultivated under identical conditions of soil, water supply and fertilizers. The fruits were harvested at the same time, when they seemed to have reached the commercial maturation. Then they were select by their weight and shape trying to have homogeneous groups.

2.3. Equipment

To study the impact response we used an impact test instrumentation already described (Chen *et al.* 1985; Ruiz- Altisent et al.1986). The impacting sphere we used had the total weight of 115.31 g. It was connected to a personal computer. Software packages described in Garcia (1988) and Ruiz-Altisent *et al.*, (1986) were applied for data acquisition and analysis.

Compression tests were made with and "Instron Universal Testing Machine", model 1122, and with a spherical indenter, at 10 mm/min..

2.4. Methods

The procedure used to carry out the impact test was the usual one with this equipement and software (Garcia, 1988). This software allows us to read and memorize a great number of data from different parameters.

We chose two different heights of fall: 12cm and 20cm and repeated twice the impact (two times at each fruit). We got values of maximum force betwen 50 N and 170 N and values of total time of impact betwen 3.20 ms and 10.0 ms.

Some of the impact response parameters are hightly related to post-harvest ripeness level in other fruits (Garcia *et al.*, 1988, Ruiz Altisent, 1990). On this work we only studied two of the: maximum value of impact force (F), in Newtons, and total impact duration (T), in miliseconds, we tried a new ratio F3/T in N/ms.

In order to observe the bruised area we smeared with ink the impact sphere and cut at the center of the bruised region and sprayed a solution 0.1 M of Pirocatecol on it (Rodriguez, 1988).

To carry out the non-destructive compression test we used the instron and a spherical indenter, the velocity was of 10 mm/min and the test reached 4 mm of depth.

3. RESULTS AND DISCUSSION

We analysed the average values of force (F), total time of impact (T) and the new ratio (F3/T) and we noticed that they show a very constant behaviour. So we made the adjustment of linear functions to those values, most of them show significant correlations and some of them are very high.

These straight lines give us a general idea of the behaviour of the parameters during the seven weeks of cold storage of the melon varieties studied.

The straight lines adjusted to the average values of maximumn force (F) had negative values of the slope, the values of (F) decrease significantly with the time of storage. Both varieties had similar changes in this parameter. As an example we can see Figure 2 and 3 where a significant correlation exists for the values of (F) and time of storage (r2 = 0,6 ; 0,7; 0,9).

The average values of total time of impact (T) show good adjustments with high significant values of correlation (r2 = 0.9) The slope of the straight lines was positive. For both varieties tested this parameter is very adequate to represent post-harvest ripening at this time of storage. Furthermore is needed to explain some significant variability observed in the data. Looking at the graphic representation of the impact duration (T) we can see that it increases together with the time of conservation as well as the ripeness level. (Figure 4 and 5). A highly accurate prediction of ripening process could be made using this parameter.

On Figure 5, for fruits 'Piel de sapo', it is obvious that at the fifth and sixth weeks of tests there were strong changes on the values of (T), meaning that a large alteration of the ripening process took place. The same happened on the fruits 'Branco da Lezíria' a week later but with a less degree of intensity.

To confirm these facts we compared these values with those obtained from the compression test, and we can easily notice that there was a coincidence of results (Figures 6 and 7).

The varieties present a similar behaviour, because they didn't show signficant differences (F = 0,01 and F = 0,08) between the corresponding regression line.

We notice that at the sixth week of testing the slope is significantly higher than all the others (F = 16,544***) and the intercept was significantly lower than all the others (F = 14,618***). We can therefore say that the most important change in the mechanical characteristics of the fruits ocurred by that time: six weeks of cold storage.

4. CONCLUSIONS

Non destructive tests like Impact and Compression can be adapted to these fruits, melon 'Piel de sapo' and 'Branco de Lezíria', in order to study their mechanical characteristics. This allow us continue working with this species and methodologies.

As in many other fruits, in the impact tests the maximum force (F) decreases significantly with conservation time and the total time (T) increases similarly (Garcia, 1988;Rodriguez, 1988; Ceballos, 1990; Ruiz-Altisent, 1990).

There is a close relationship between the results of the Impact test and the Compression test. They give similar results, which show us that at 6ºC + -1ºC it is possible to store melons during periods of six weeks without great changes in their mechanical properties or sensory acceptance.

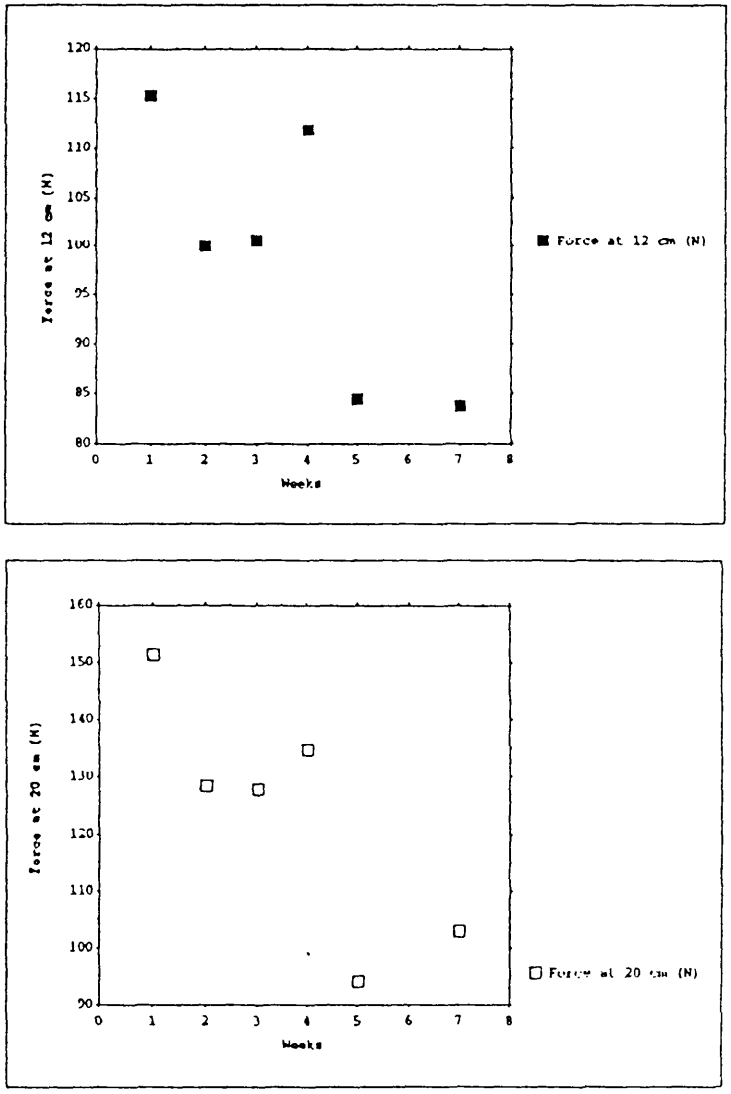


Fig. 2 Graphic representation of average values of Maximum Force of Impact (F) during storage time for fruits 'Branco da Lezíria', at 12 cm (a) and 20 cm (b) of heigh of fall.
The equations of both lineal regressions are: $y = 4,8x + 117,1$ with $r^2 = 0,6$ for (a) and $y = -8,1x + 153,2$ with $r^2 = 0,7$ for (b). We should notice that maybe it is possible to adjust another function; it will be necessary further tests.
Don't forget that any average value correspond to a large number of data from 20 values for the first date until 80 for the last date of tests.

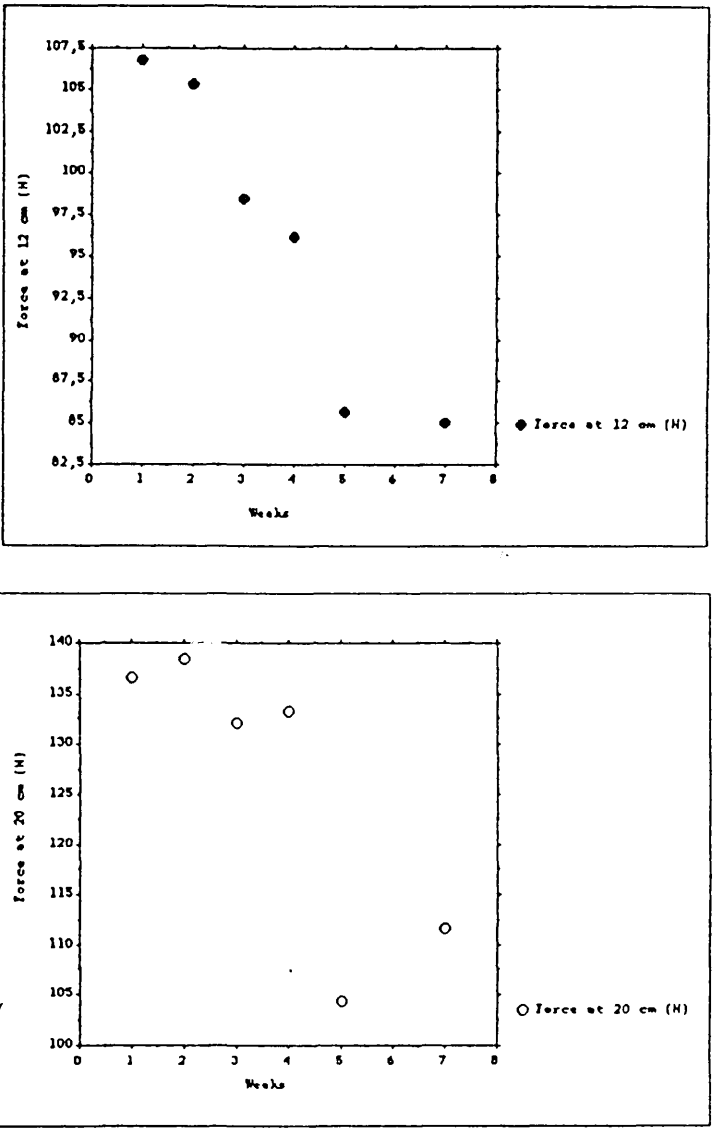
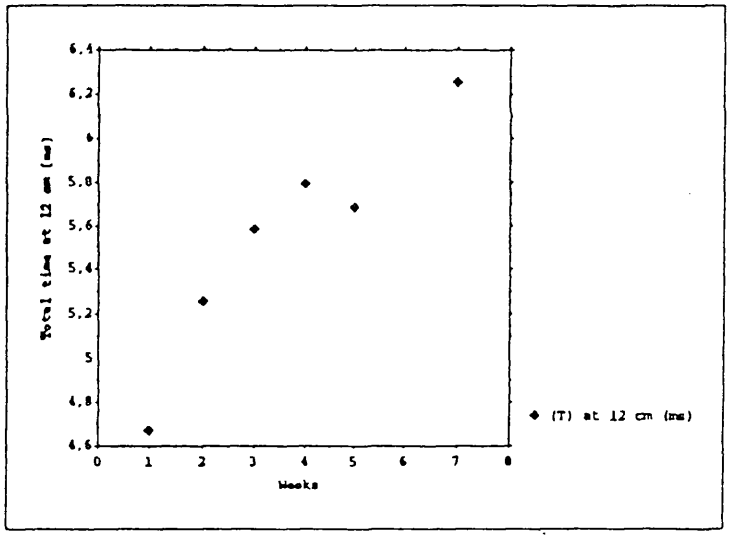


Fig. 3. Graphic representation of average values of Maximum Force of Impact (F) during storage time for fruits 'Piel de Sapo', at 12 cm (a) and 20 cm (b) of heigh of fall.
The equations of both lineal regressions are: $y = -4,1x + 111,3$ with $r^2 = 0,9$ for (a) and $y = -5,4 + 146,1$ with $r^2 = 0,7$ for (b). Maybe it is possible to adjust another function.
The average values of the first date correspond to 20 data and 80 for the last one.



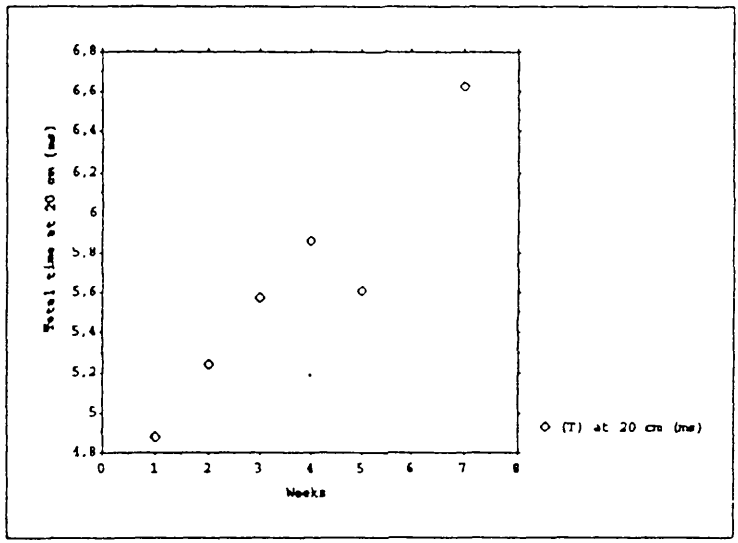
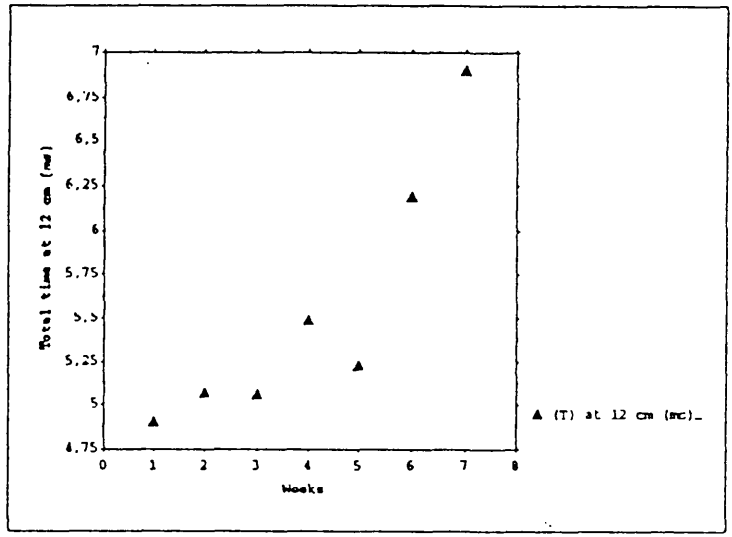


Fig. 4. Graphic representation of average values of Total Time of Impact (T) for fruits 'Branco da Lezíria', at 12 cm (a) and 20 cm (b) of heigh of fall.
The equations of the lineal regressions are: $y = 0,2x + 4,7$ with $r^2 = 0,9$ for (a) and $y = 0,3x + 4,7$ with $r^2 = 0,9$ for (b). Maybe it is possible to adjust another function.
Any average value correspond to a large number of data: 20 for the first date until 80 for the last one.



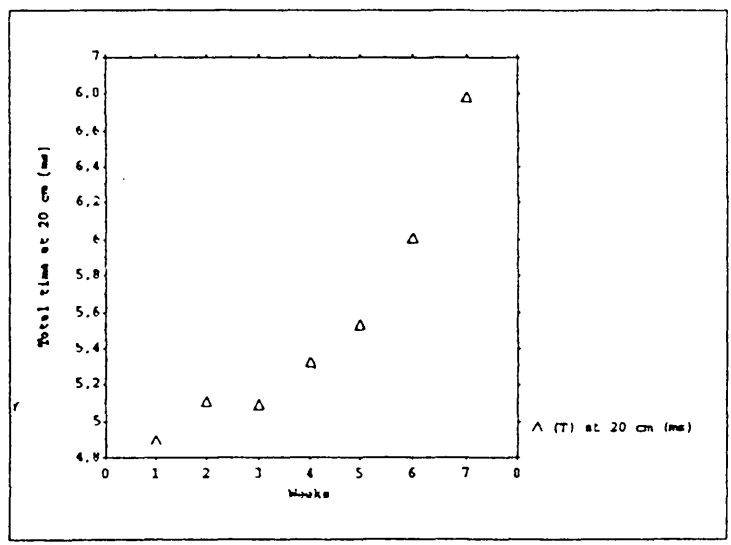


Fig. 5. Graphic representation of average values of Total Time of Impact (T) for fruits 'Piel de Sapo', at 12 cm (a) and 20 cm (b) of heigh of fall to each variety.
The equations of the lineal regressions are similar for both heighs: $y = 0,3x + 4,4$ with $r^2 = 0,8$ for (a) and $r^2 = 0,9$ for (b). Here it is very easy to notice that it will be correct to adjust curves on both graphs.
The number of data are 20 at the first date and 80 at the last date.

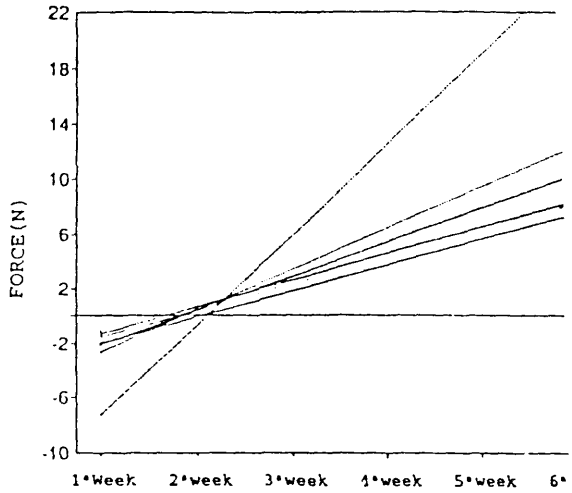


Fig. 6. Lineal regression for values of Maximum Force of Compression for fruits 'Branco da Lezíria'.
Here the groups correspond to the fruits tested in each date of tests. Notice that the slope and intercept of the last group are quite different from the others.

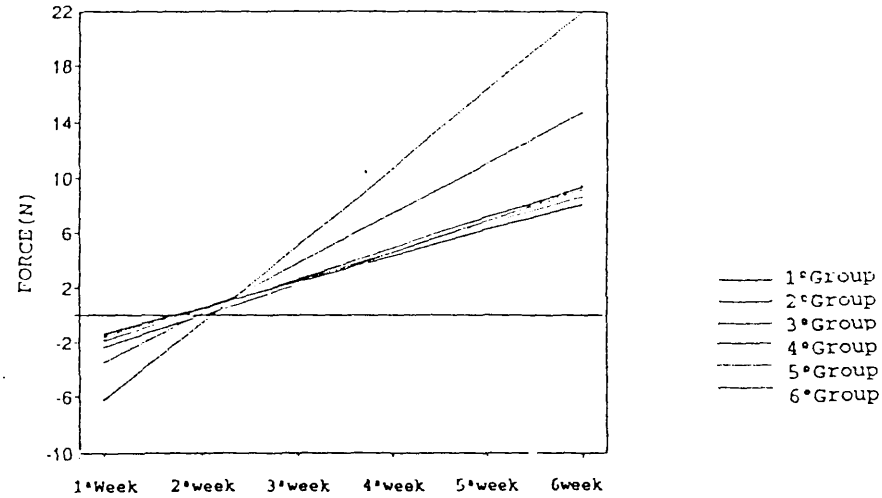


Fig. 7. Lineal regression for values of Maximum Force of Compression for fruits 'Piel de Sapo'
The groups correspond to the fruits tested in each date of tests. We should notice that the slopes and intercepts of the two last groups corresponding to fifth and sixth dates of tests are very different from the others.

Impacts from a height of 20 cm of fall show more evident results than using the height of 12 cm. We think it will be better to maintain the height of 12 cm and to improve the energy of impat (E imp.) by increasing the weight of the testing sphere.

Even with low values of (E imp.), without reaching the bioyield point thus with no bruising, it is possible to measure many useful parameters of impact response in these fruits.

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